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FREE-FLIGHT BALLISTICS RANGE TESTS OF MODELS FOR THE GE PROGRAM 1-62 (U)

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Ballistics Research Report 60

FREE-FLIGHT BALLISTICS RANGE TESTS OF MODELS FOR THE GE PROGRAM 1-62

Prepared by:

Jeanne B. Jusino

ABSTRACT: Data are presented for seven free-flight shots of models of the 1-62 program made in the Pressurized Ballistics Range No. 3 at the Naval Ordnance Laboratory. A drag curve was obtained for the Mach number range of 4 through 7. Stability coefficients were also obtained and are presented in both graphical and tabular form. The Reynolds numbers for these shots were 0.5 to 2.4 million. Shadowgraph pictures are also included for flow studies.

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NOLTR 62-6 31 December 1962

FREE-FLIGHT BALLISTICS RANGE TESTS OF MODELS FOR THE GE PROGRAM 1-62

This report presents the results of model firings made in the Pressurized Ballistics Range No. 3 at the Naval Ordnance Laboratory at the request of the General Electric Company with funds provided by the Air Force Ballistic Missile Division. The work was performed under task number NOL-570.

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R. E. ODENING
Captain, USN
Commander

A. E. Seigel
A. E. SEIGEL
By direction

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SYMBOLS

A	axial moment of inertia
B	transverse moment of inertia
C_D	total drag coefficient based on maximum cross-sectional area
C_{D_o}	total drag coefficient corrected to zero-yaw
CG	center of gravity
C_{L_α}	slope of lift coefficient
C_{M_α}	slope of pitching moment coefficient
$C_{M_q} + C_{M_{\dot\alpha}}$	slope of yaw damping moment coefficient
C_{N_α}	slope of normal force coefficient
d	maximum diameter of model
k	parameter used to remove the effect of yaw from the drag coefficients
M	Mach number
P	range test pressure
P.E.	probable error of coefficients based on accuracy of data fitting
Re_d	Reynolds number, $\rho Vd/\mu$
V	velocity
δ^2	mean squared yaw
μ	coefficient of viscosity
ρ	air density

INTRODUCTION

1. Eight models were fired in the Pressurized Ballistics Range No. 3 using a 76-40 powder gun in order to obtain drag and stability data for GE Configuration XXX B. A sketch of this configuration can be found in Figure 1. A description of the Pressurized Ballistics Range No. 3 is given in reference (a). This report presents the drag and stability data obtained for Mach numbers 4 through 7 and Reynolds numbers 0.5 to 2.4 million.

MODEL DETAILS

2. The XXX B models were constructed with a hevimet nose and a hollow titanium afterbody. The forebody was held in place with EC-1294 Epoxy cement. This junction proved very successful in these high velocity powder-gun shots. A photograph of the model and its sabot is shown in Figure 2. Detailed model measurements are presented in Table I.

DISCUSSION AND RESULTS

3. Drag coefficients were obtained for all shots except one where the model hit the first baffle plate in the range. These drag coefficients were obtained for Mach numbers ranging from 4 through 7. Tests were conducted at atmospheric pressure for five of the shots and, for the other two shots, the range was evacuated to 0.2 atmospheres in order to vary the Reynolds number. The experimental drag points (Figure 3) fall very close to the theoretically predicted drag curve furnished by the General Electric Company. The data points where the mean squared yaw was over three degrees squared were corrected to zero yaw using the equation:

$$C_{D_o} = C_D - k\delta^2$$

The drag reduction was carried out using the method of reference (b). The drag coefficients are listed in Table II.

4. The stability coefficients presented in Table III were also reduced according to the method described in reference (b). As a result of the firings the configuration was

found to be statically and dynamically stable. A sample of the motion for these models is presented in Figure 4 for Round 4127. The stability coefficients are plotted in Figure 5 as a function of Mach number. For rounds 4132 and 4133 only an estimated C_{M_α} was obtained because of insufficient information from these launchings. Sabot pieces entered the range and hit several stations causing the photographic plates to be broken or overexposed. To obtain stability coefficients data are needed from a minimum of thirteen stations.

5. For each round there is included a shadowgraph for flow studies (Figures 6 through 12). Where the model was near zero yaw, there appears to be laminar flow on the cylindrical portion of the body. From these shadowgraph photographs, it also appears that the boundary layer separated from the body slightly forward of the skirt for all shots except 4133.

CONCLUSIONS

6. Configuration XXX B was found to be statically and dynamically stable.

7. The drag coefficients fell close to the predicted curve. For the Mach number range tested, C_D varied from 0.2 to 0.1.

8. EC-1294 Epoxy cement proved to be a strong bonding material at the junction of two metals used in the construction of the models for firings up to Mach 7 using a powder gun.

REFERENCES

(a) May, A. and Williams, T. J., "Free-Flight Ranges at the Naval Ordnance Laboratory," NavOrd Report 4063 (1955)

(b) Murphy, C. H., "Data Reduction for the Free-Flight Spark Ranges," BRL Report No. 900 (1954)

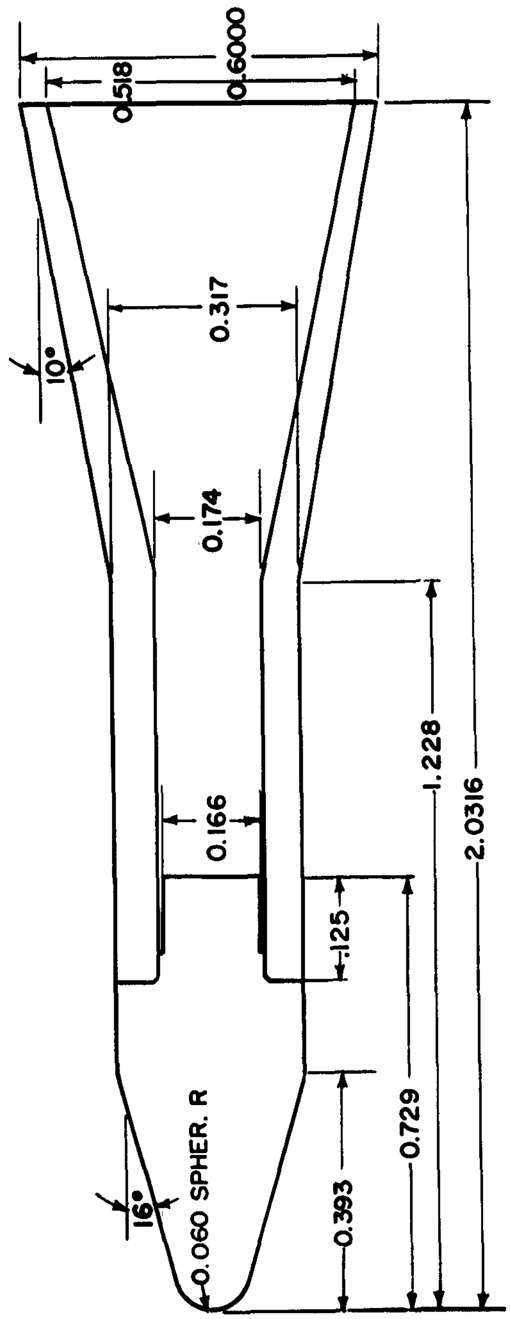

FIG. I SKETCH OF CONFIGURATION XXX B

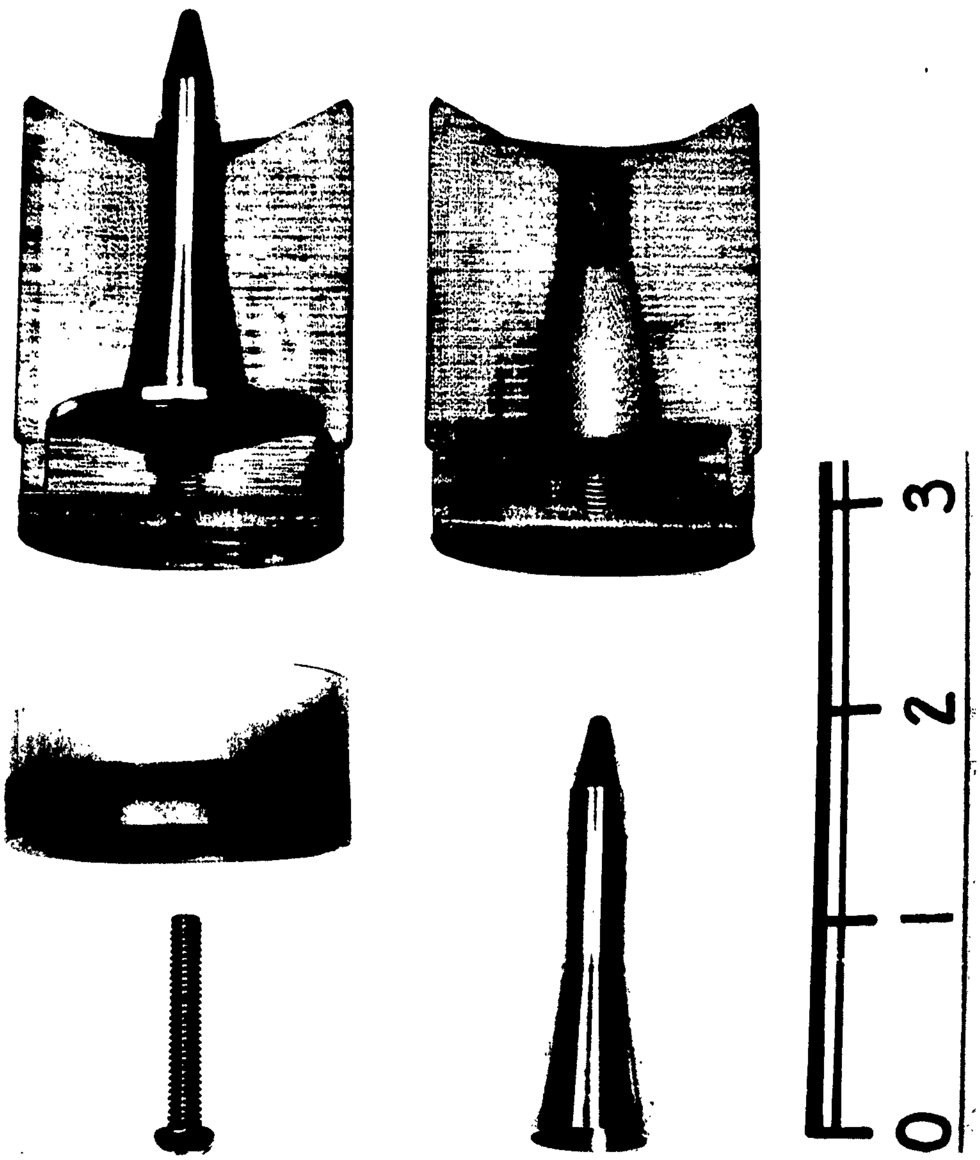

FIG. 2 CONFIGURATION XXX B AND SABOT

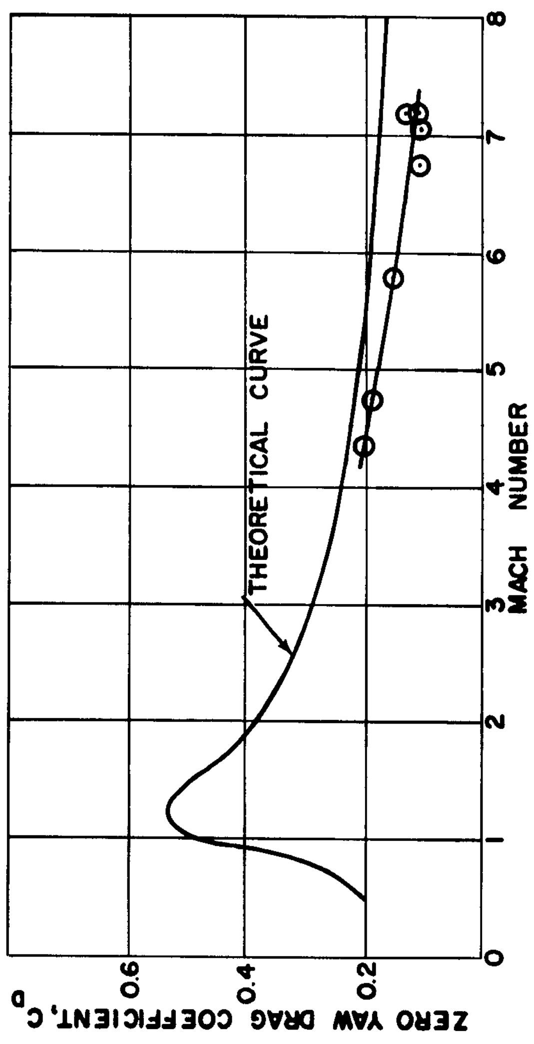

FIG.3 ZERO YAW DRAG COEFFICIENT AS A FUNCTION OF MACH NUMBER

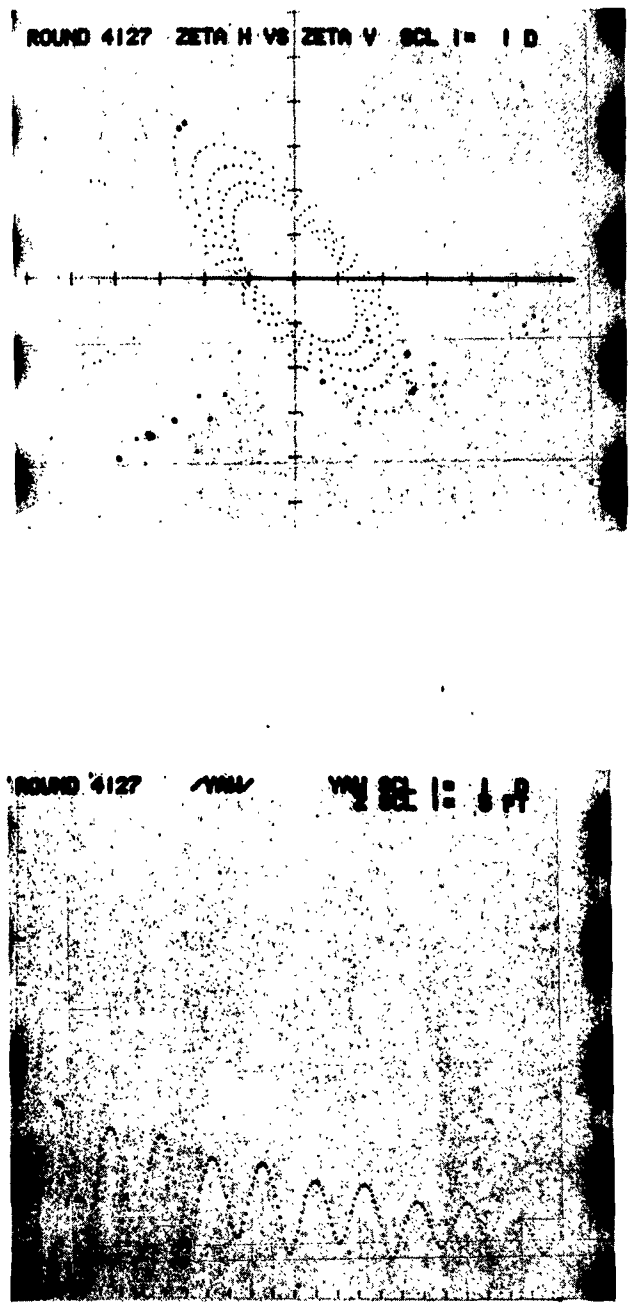

FIG.4 COMPLEX YAW PLOTS FOR ROUND 4127

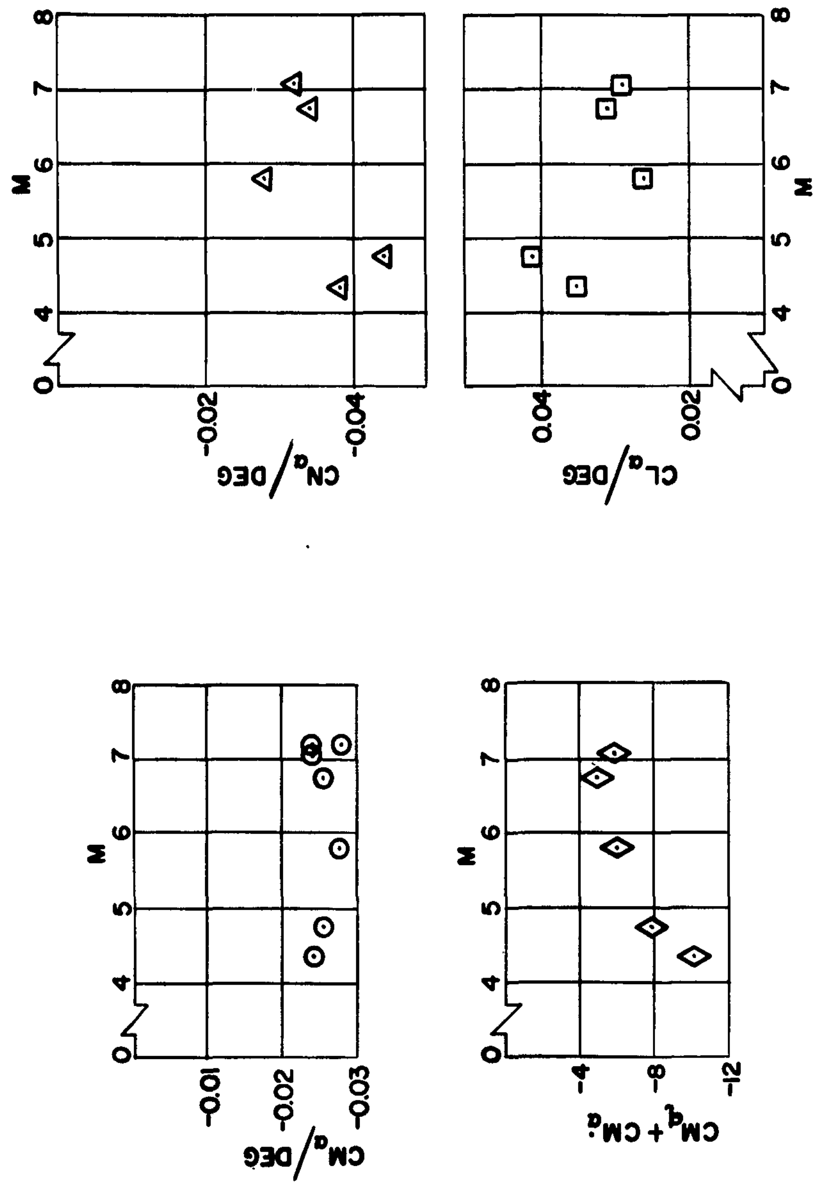

FIG. 5 STABILITY COEFFICIENTS AS A FUNCTION OF MACH NUMBER

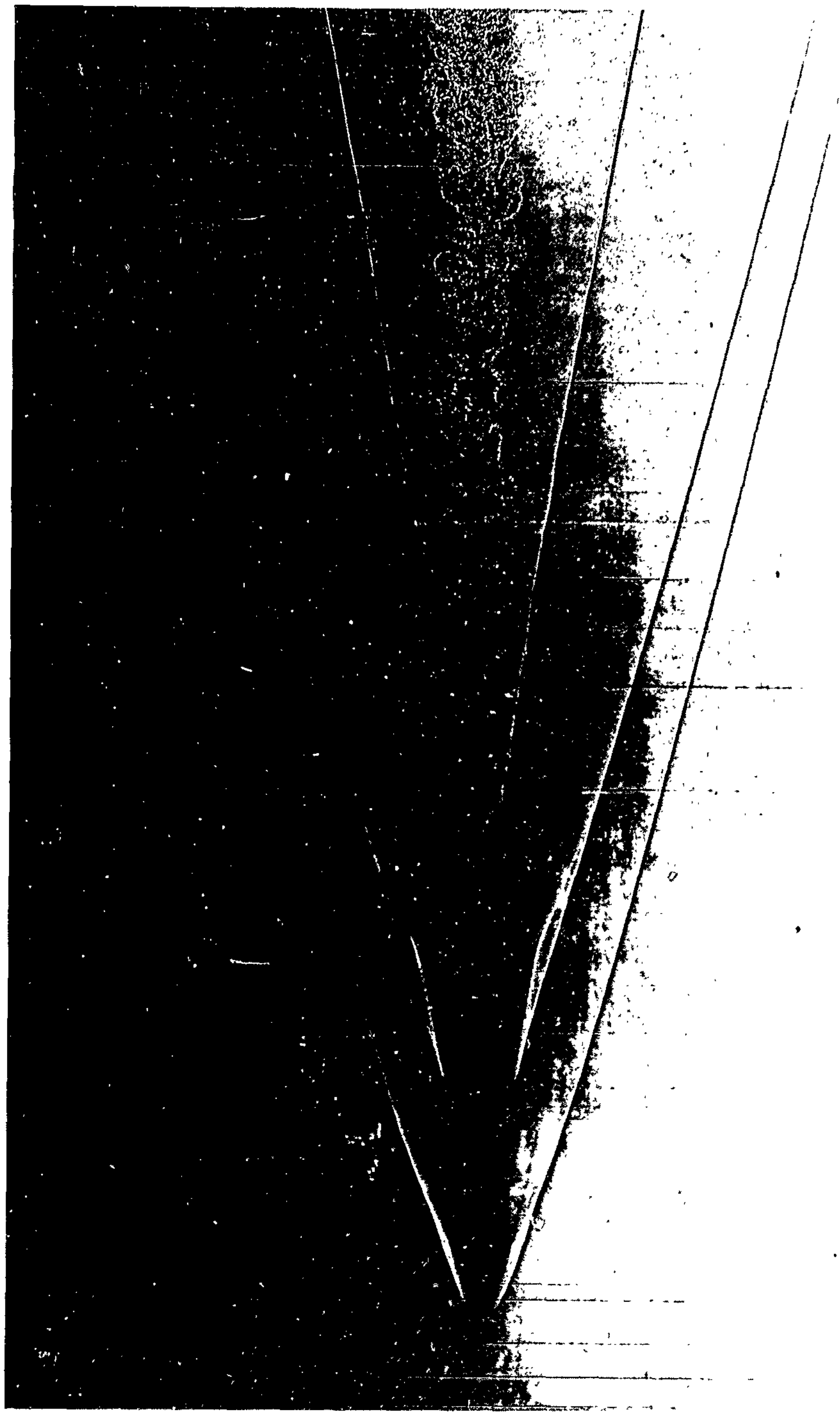

FIG. 6 SHADOWGRAPH OF ROUND 4126, STATION 6V, M = 4.827

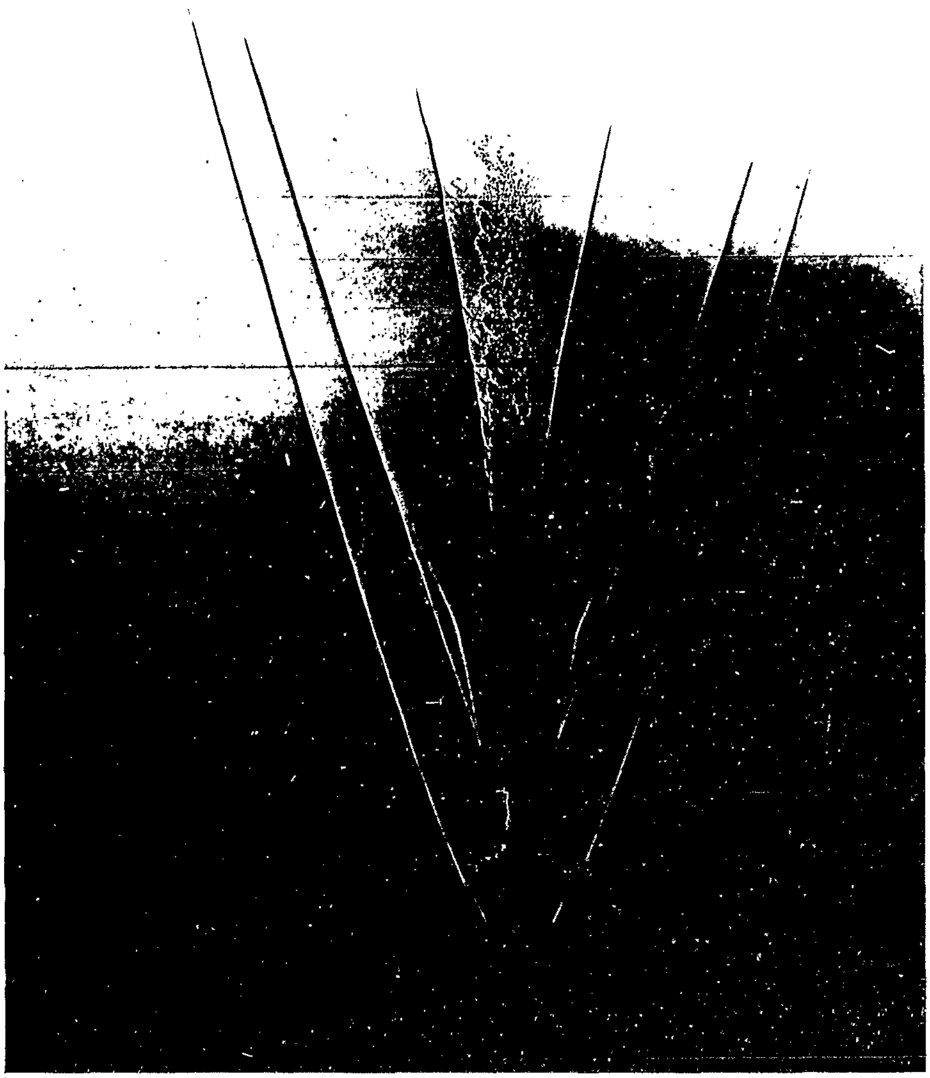

FIG. 7 SHADOWGRAPH OF ROUND 4127, STATION 23V, M = 4.099

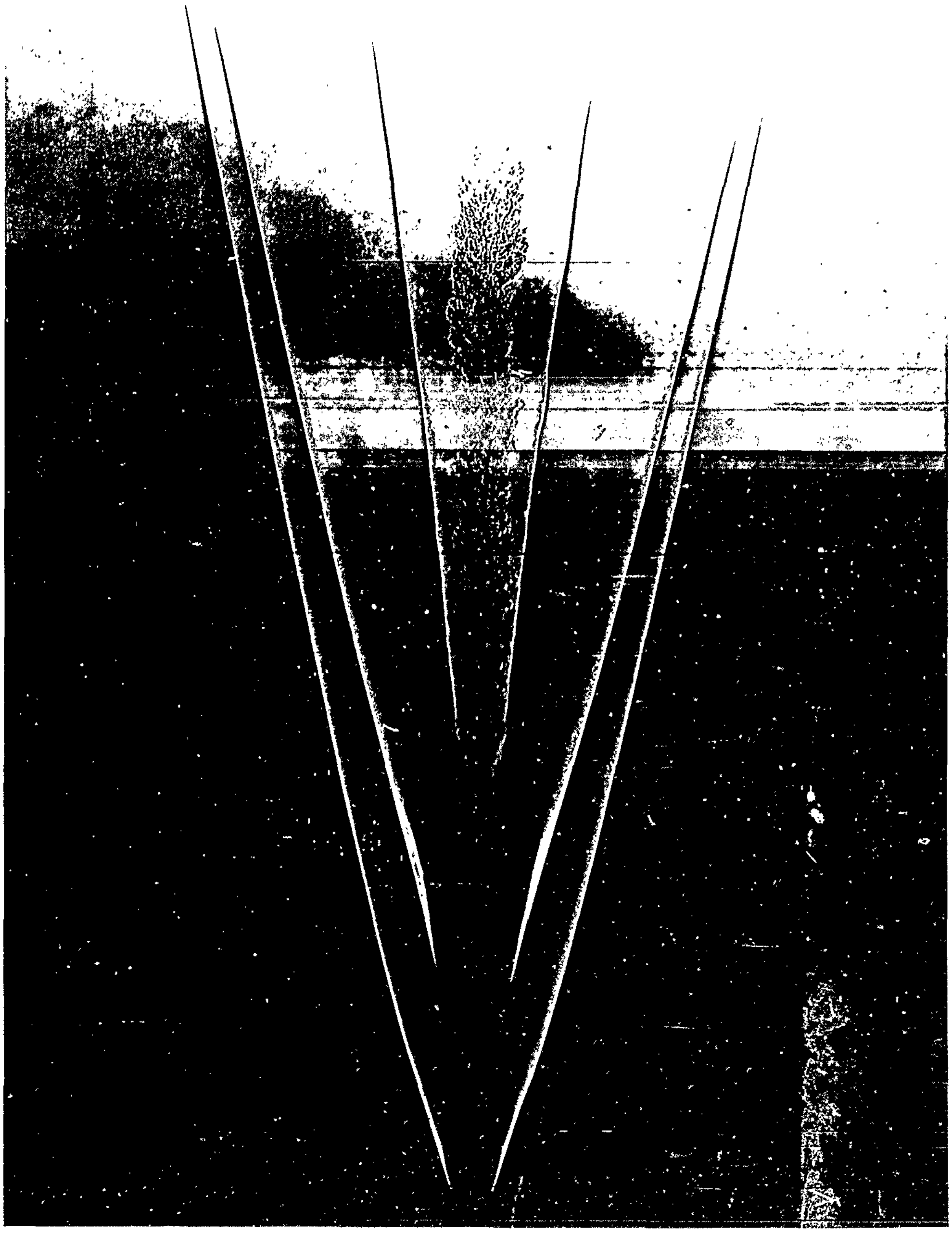

FIG. 8 SHADOWGRAPH OF ROUND 4128, STATION 14V, M= 5.888

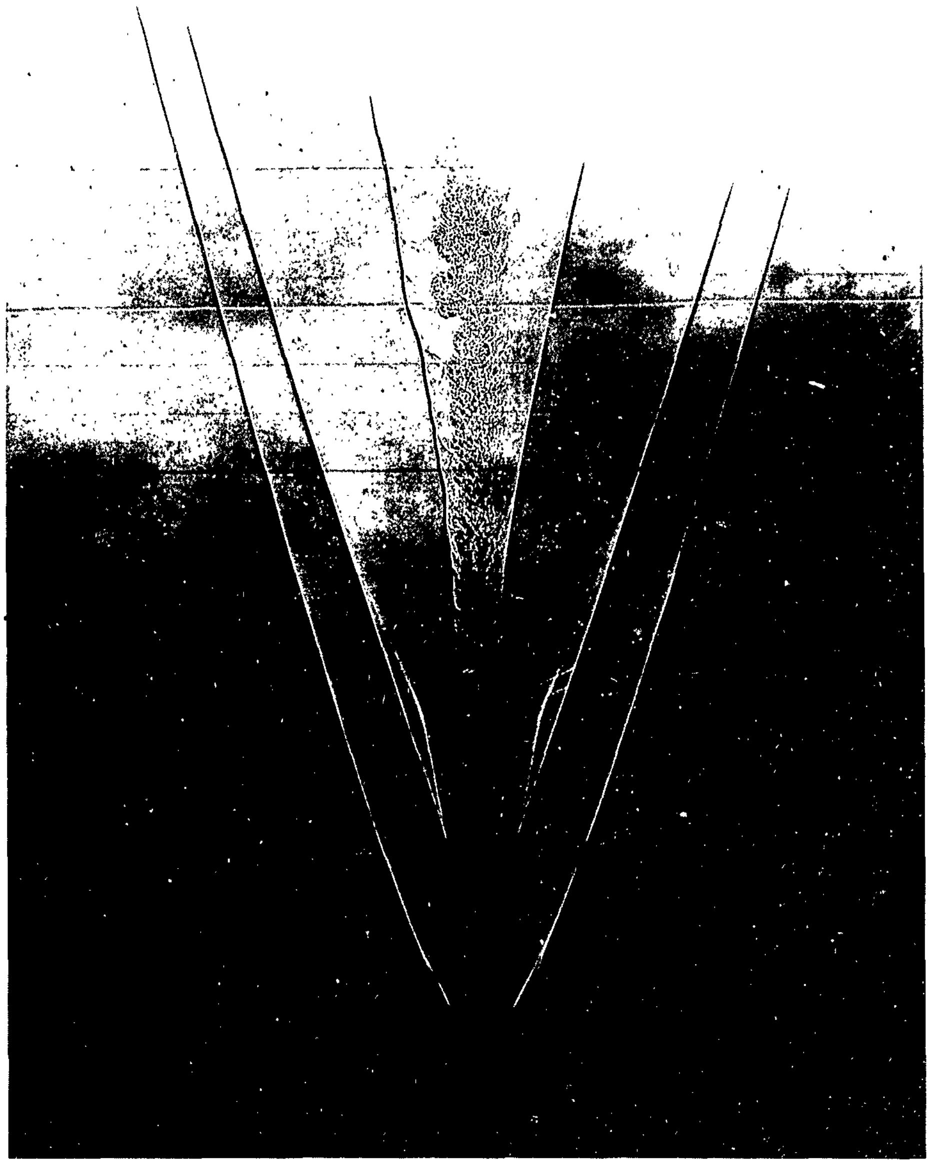

FIG. 9 SHADOWGRAPH OF ROUND 4129, STATION 22V, M = 6.522

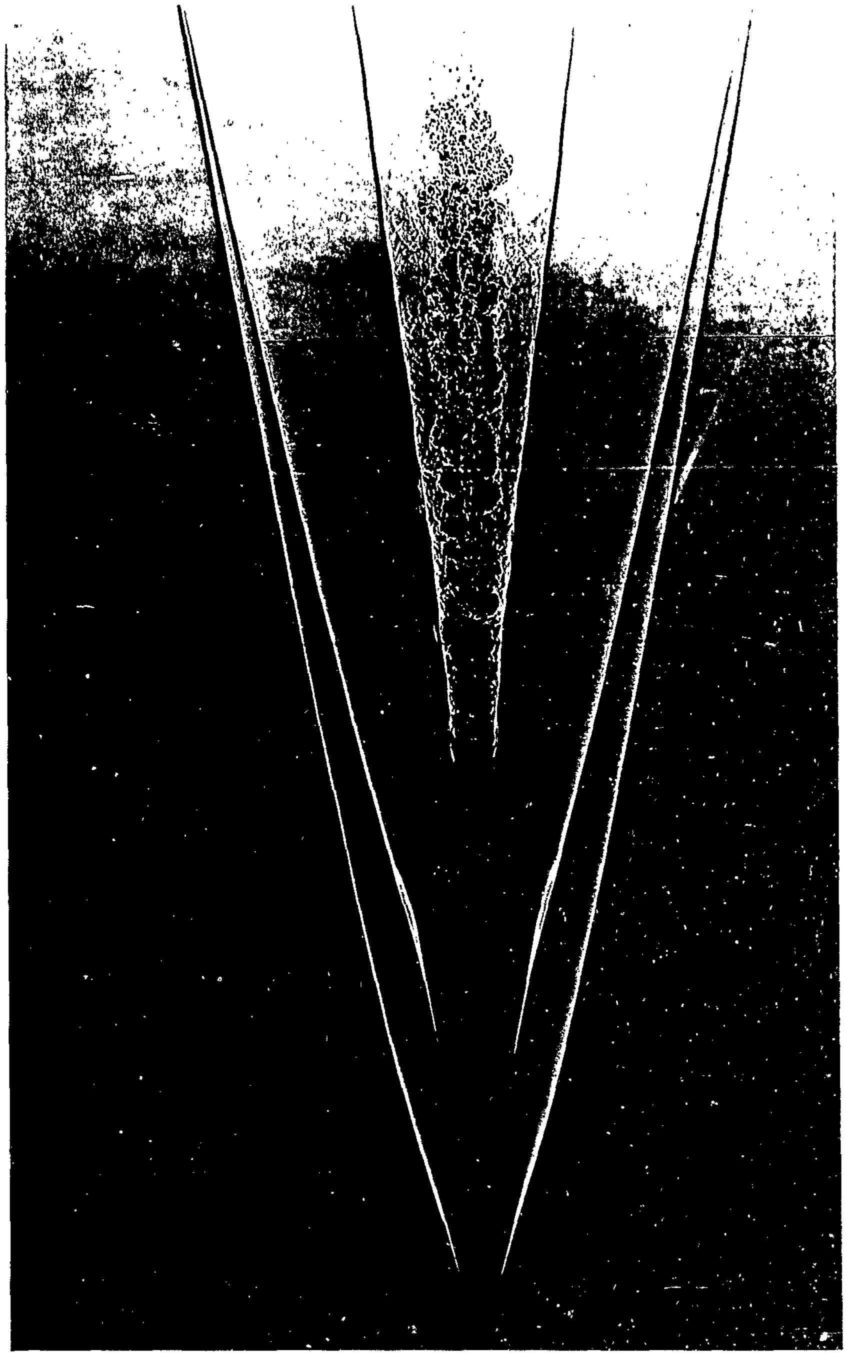

FIG.10 SHADOWGRAPH OF ROUND 4131, STATION 18V, M=6.996

FIG. 11 SHADOWGRAPH OF ROUND 4132, STATION 5V, M= 7.215

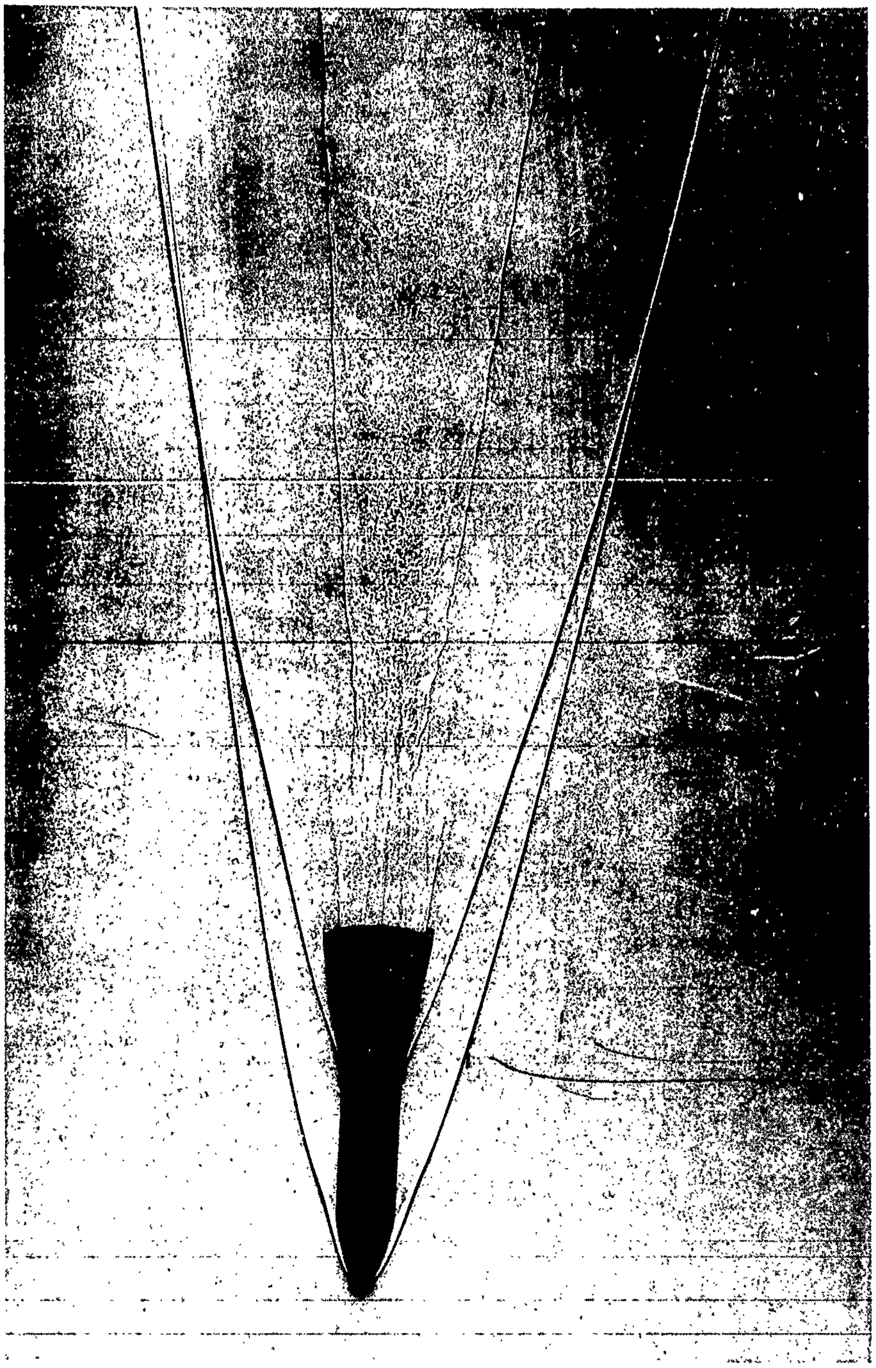

FIG. 12 SHADOWGRAPH OF ROUND 4133, STATION 6V, M = 7.267

TABLE I

MODEL PHYSICAL MEASUREMENTS

Shot	Body Dia. (In.)	Base Dia. (In.)	Length (In.)	Weight (Gm.)	CG from Nose (In.)	A (Gm.In.^{2})	B (Gm.In.^{2})
4126	0.317	0.600	2.032	14.8333	0.803	0.299	4.618
4127	0.317	0.599	2.032	14.7359	0.804	0.300	4.649
4128	0.317	0.600	2.032	14.9189	0.801	0.297	4.666
4129	0.317	0.600	2.031	14.8126	0.801	0.296	4.641
4131	0.317	0.599	2.032	15.0051	0.801	0.303	4.714
4132	0.317	0.600	2.031	15.0014	0.801	0.302	4.708
4133	0.317	0.600	2.032	14.9913	0.800	0.300	4.694

TABLE II

DRAG DATA

Round	M	Re x 10^{-6}	δ^2	C_D	±P.E.	C_{D_o}	P (Atm.)
4126	4.754	1.612	2.2	0.1849	0.0007		1.0
4127	4.358	1.465	2.7	0.2001	0.0001		1.0
4128	5.812	1.955	1.5	0.1528	0.0001		1.0
4129	6.761	2.323	42.9	0.1826	0.0003	0.1097	1.0
4131	7.081	2.405	21.7	0.1445	0.0002	0.1077	1.0
4132	7.209	0.506	13.2	0.135	0.005	0.113	0.2
4133	7.213	0.484	36.1	0.1935	0.0005	0.1322	0.2

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TABLE III

STABILITY COEFFICIENTS

Round	M	C_{M_α}/Deg. ±P.E.	C_{N_α}/Deg. ±P.E.	C_{L_α}/Deg. ±P.E.	$C_{M_q} + C_{M_{\dot\alpha}}$ ±P.E.	±P.E. Yaw (Deg.)	±P.E. Swerve (In.)	CP - CG (Cal.)
4126	4.754	-0.0254 0.0003	-0.044 0.009	0.041 0.009	-7.9 2.5	0.2	0.018	0.576
4127	4.358	-0.0243 0.0001	-0.038 0.010	0.035 0.010	-10.2 1.3	0.1	0.013	0.634
4128	5.812	-0.0279 0.0003	-0.028 0.022	0.026 0.022	-6.1 2.8	0.2	0.016	0.987
4129	6.761	-0.0256 0.0002	-0.034 0.003	0.031 0.003	-5.0 2.0	0.6	0.021	0.756
4131	7.081	-0.02401 0.00005	-0.032 0.003	0.029 0.003	-5.9 0.4	0.1	0.014	0.762
4132	7.209	-0.024 (Est.)						
4133	7.213	-0.028 (Est.)						

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Free-flight	FREG	Mach	MACH	Metals	META
Ballistic range	BALR	4	4xØØ	Hollow	HOLL
Model (tests)	MODET	5	5xØØ	Titanium	TITN
General Electric	GENL	6	6xØØ	Afterbody	AFTE
Model	MODE	7	7xØØ	Body (tests)	BODYT
Test	TEST	Stability	STBI	Body	BODY
Facilities	FACI	Coefficients	COEF	Resins	RESI
Firings	FIRI	Shadowgraphs	SHAD	Configuration	COFI
Powder	POWD	Flow	FLOW	Configuration (tests)	COFIT
Gun	GUNS	Epoxy	EPOX	Missiles	MISL
Drag	DRAG	Cement	CEME	Aerodynamics	AERD
Curve	CURV	Bond	BOND	Missile (tests)	MISLT

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(NOL technical report 62-6)
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Data are presented for seven free-flight shots of models of the 1-62 program made in the Pressurized Ballistics Range No. 3 at the Naval Ordnance Laboratory. A drag curve was obtained for the Mach number range of 4 through 7. Stability coefficients were also obtained and are presented in both graphical and tabular form. The Reynolds numbers for these shots were 0.5 to 2.4 million. Shadowgraph pictures are also included for flow studies.

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